J. W. Miller Co.

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INSTRUCTION MANUAL

FOR THE

Q COMPARATOR TYPE 265-A

GENERAL ELECTRIC CO.
Instrumentation & Control
228 W. Florence Ave.
Inglewood, Calif. 90301

BOONTON RADIO CORPORATION
BOONTON, NEW JERSEY
U. S. A.

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Printed in U.S.A.

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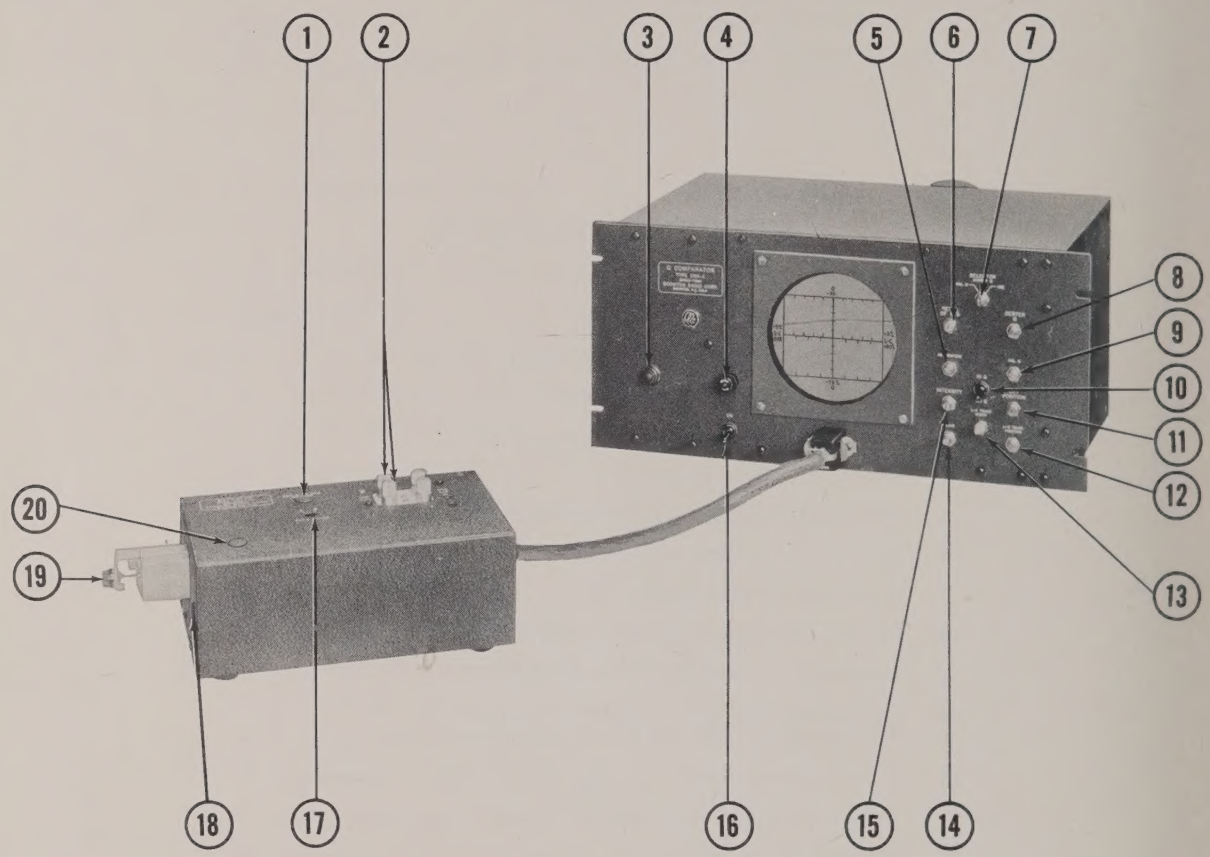


Figure 1. Type 265-A Q Comparator — Control Layout

1. SET Q OF STD — COARSE
2. Test Terminals
3. Pilot Lamp
4. Fuse
5. ASTIGMATISM
6. SET Q OF STD — FINE
7. SELECTOR
8. CENTER Q
9. CAL Q
10. HI Q — LO Q
11. DOT POSITION
12. L-C TRACE POSITION
13. L-C TRACE WIDTH
14. FOCUS
15. INTENSITY
16. Power Switch
17. FREQ RANGE
18. Rotating Capacitor Shaft Access Hole
19. Type 520-A Oscillator Inductor
20. Rotating Capacitor Shaft Detent

SECTION I

DESCRIPTION

GENERAL

The Type 265-A Q Comparator has been designed for instantaneous testing of coils, capacitors, and resistors in a frequency range of from 200 kc to 70 mc. The instrument operates on a comparative testing principle, with the results obtained from testing a known standard being compared with the results obtained from testing a production component in the same test circuit.

A dot generated by the instrument is initially set up at the exact center of a cathode-ray tube with the known standard connected in the test circuit. The standard is then removed and a production component is connected in its place. Any displacement of the dot from the original center position on the CRT represents a difference in characteristics between the standard and the production component. Horizontal and vertical axis scale markings imprinted on the CRT provide a direct means for reading this difference in percentage of capacitance, inductance, and Q.

Physically the Q Comparator is comprised of two separate units: the Indicator Unit, containing the power supply and the CRT display control circuits; and the Oscillator-Detector Unit containing the oscillator, detector, and test circuit. The two units are interconnected by means of a cable and plug.

SPECIFICATIONS

RADIO FREQUENCY CHARACTERISTICS

RF Range

Total Range: 200 kc to 70 mc

Number of Ranges: 10 (through use of eight Type 520-A Oscillator Inductors

Band Ranges:

Inductor	*Range*	*Frequency*
520-A1	B	50 — 70 mc
520-A2	A	30 — 50 mc
520-A3	B	15 — 30 mc
520-A4	B	8 — 16 mc
520-A5	A	2 — 4 mc
	A	4 — 8 mc
520-A6	A	550 kc — 1 mc
	A	1 — 2 mc
520-A7	B	300 — 500 kc
520-A8	A	200 — 300 kc

RF Accuracy: May be set to within ±0.5% with external standard

Q MEASUREMENT CHARACTERISTICS

Q Range: 30 to 500

% Q Range: ±25% of standard

% Q Accuracy: ±5% on 25% range

% Q Calibration: increments of 5%

INDUCTANCE CAPACITANCE MEASUREMENT CHARACTERISTICS

L Range: 0.15μh to 15 mh*

C Range: 5$\mu\mu$f to 0.01μf*

R Range: 500Ω to 20 megΩ*

*Actual range depends upon test frequency

% L-C Range: ±5% or ±20% of standard full scale)

% L-C Accuracy: Direct reading to ±20% of % L-C range (for L between 1μh and 15 mh and C between 500$\mu\mu$f and 0.01μf)

Comparison to ±10% of limit standards (for L between 0.15μh and 15mh and C between 5$\mu\mu$f and 0.01μf)

% L-C Calibration: 1% increments on ±5% range
5% increments on ±20% range

ACCESSORIES

Furnished: 1 each Type 520-A Oscillator Inductor (covering range specified by customer)

Available: Type 520-A Oscillator Inductors (providing ten ranges as specified above)
Type 103-A Inductors

TUBE COMPLEMENT

3 — OA2	2 — 12AU7A
4 — 1N55A	6 — 12AX7
1 — 5ABP1	4 — M150 Rectifier
2 — 6AU8A	2 — NE2
1 — 6C4	

PHYSICAL CHARACTERISTICS

Mounting:

Indicator Unit — cabinet for bench use (May be mounted in 19-inch rack.)

Oscillator-Detector Unit — cabinet for bench use

Dimensions:

Indicator Unit — Height: 9-11/32 inches
Width: 19 inches
Depth: 10¼ inches

Oscillator-Detector Unit — Height: 5-11/64 inches
Width: 10-13/16 inches
Depth: 8⅛ inches

Weight (both units):
Net: 40 lbs.
Gross Domestic: 50 lbs.
Gross Export: 82 lbs.
Legal Export: 46 lbs.

POWER REQUIREMENTS

265-A: 105-125 volts, 60 cps, 115 watts

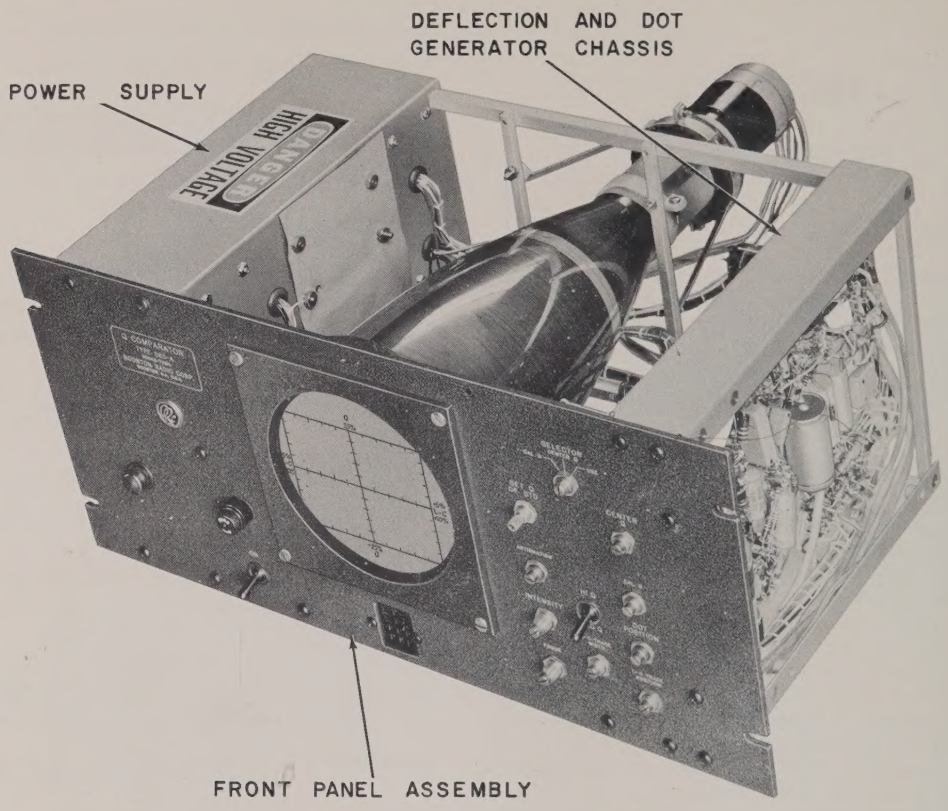


Figure 2. Indicator Unit — Cover Removed

CONTROLS AND INDICATORS

The following controls are adjusted during the set up procedure only, and should not be disturbed during operation of the Q Comparator. See Figures 1 and 3 for location of controls.

Control	*Function*
Power Switch	Connects instrument to power source
Pilot Lamp	When lighted, indicates that the instrument circuits are energized
Motor Switch (Rotating Capacitor)	Controls power to driving motor for rotating sweep capacitor
FREQ RANGE Switch	Selects A or B frequency range as required by oscillator inductor in use
520-A Oscillator Inductor Frequency Tuning Control	Tunes oscillator output frequency
SELECTOR Switch	Provides proper circuit connections for adjusting CRT display
CENTER Q	Adjusts vertical position of CRT display
L-C TRACE POSITION	Adjusts horizontal position of CRT display
CAL Q	Adjusts gain of vertical amplifier
L-C TRACE WIDTH	Adjusts gain of horizontal amplifier
INTENSITY	Adjusts brightness of CRT display
High-Low Capacitance Switch	Selects test circuit capacitance range — Strap open for low capacitance
HI Q — LO Q Switch	Changes level of oscillator output so that the SET Q OF STD controls are effective when measuring both low-Q and high-Q components (Generally operated in LO Q position)
Resonating Capacitors	Adjust capacitance in test circuit
SET Q OF STD — COARSE	Coarse adjustment of oscillator injection into test circuit

SET Q OF STD — FINE	Fine adjustment of oscillator injection into test circuit
DOT POSITION	Provides means for positioning dot to peak of resonance curve
FOCUS	Adjusts sharpness of dot
ASTIGMATISM	Adjusts symmetry of dot

SECTION II

OPERATING INSTRUCTIONS

INSTALLATION

Remove the Q Comparator from its packing carton and place it on a level test bench or table; the Oscillator-Detector Unit at the front of the test position and the Indicator Unit at the rear. The Indicator Unit has provision for mounting in a 19-inch rack if this type installation is desired.

Plug the connector on the Oscillator-Detector Unit cable into the receptacle below the CRT on the Indicator Unit. Install a Type 520-A Oscillator Inductor, of appropriate frequency range, in the socket at the left side of the Oscillator-Detector Unit. Set the FREQ RANGE switch to the correct frequency range, as indicated on the Oscillator Inductor scale label, and adjust the Oscillator Inductor frequency tuning control to the desired test frequency.

Connect the power cord at the rear of the Indicator Unit to a 105 to 125-volt, 60-cycle power source. Set the Power Switch to the ON position and allow the Q Comparator to warm up for at least ½ hour.

INITIAL SET UP PROCEDURE

The following procedure should be performed before the Q Comparator is put into operation, from time to time during prolonged usage, and after tube or other component replacements.

Center Frequency Tuning

The Q Comparator is tuned to the desired center frequency by means of the 520-A Oscillator Inductor plugged into the left side of the Oscillator-Detector Unit. If greater accuracy than that afforded by the 520-A Oscillator Inductor calibration is desired, the Oscillator Inductor frequency adjustment may be refined as follows:

1. Connect a frequency standard, meter, or counter across one set of HI and GND binding posts on the Oscillator-Detector Unit.
2. Remove the button plugs at the top left-hand corner and left side of the Oscillator-Detector Unit cover.
3. Turn the rotating capacitor shaft by pressing the rubber eraser end of a wooden pencil against the shaft end through the hole in the left side of the cover (Figure 1). Hold the detent plunger (accessible through the hole in the top of the cover) depressed, and rotate the shaft until it is detented.
4. With the capacitor shaft in this detented position, refine the Oscillator Inductor frequency tuning control adjustment to obtain the desired frequency.
5. Release the capacitor detent and turn on the capacitor drive motor. The displayed center frequency will now be within ±3% of the frequency of the standard. If a still more precise setting is desired, see "Precise Setting of Test Circuit Center Frequency" in the Appendix.

CENTER Q Adjustment

Set the SELECTOR switch to the CENTER Q position and turn the INTENSITY control full clockwise. Adjust the CENTER Q control until a horizontal trace is displayed on the CRT. Sharpen the display with the FOCUS and ASTIGMATISM controls, then adjust the CENTER Q control until the trace is displayed along the center-line axis (0% Q) of the Q scale on the CRT.

CAL Q Adjustment

Set the SELECTOR to the CAL Q position and adjust the CAL Q control until the CRT trace is aligned with the —25% marking at the bottom of the Q scale. Switch the SELECTOR to the CENTER Q position and recheck the CENTER Q adjustment.

L-C Trace Adjustment

Set the SELECTOR to the CENTER Q position and the L-C TRACE WIDTH control inner slotted shaft to the ±20% (counter-clockwise) position. Adjust the L-C TRACE WIDTH control outer, knurled shaft and the L-C TRACE POSITION control until the displayed trace extends from the left-hand vertical dashed line to the right-hand vertical dashed line at the extremes of the L-C scale. The horizontal L-C scale will now read, directly, per cent variations in L or C up to ±20% compared to a standard for values of L from 1.0μh to 15mh and for values of C from 500μμf to 0.01μf. For other values, tolerance limits must be set up as explained later in this section under "Establishing Tolerance Limits".

±5% Trace Width Adjustment

After the Q Comparator has been adjusted to provide ±20% trace width, as explained under "L-C Trace Adjustment", the instrument may be switched to provide ±5% sweep width by merely rotating the L-C TRACE WIDTH control inner shaft to the ±5% (clockwise) detent position. A slight centering error may be apparent in the ±5% position. This may be corrected by readjusting the L-C TRACE POSITION control.

Setting Q of Standard (Figure 4)

Before the Q Comparator can be used to test a component, the CRT display must be set up with a measured standard of the test component resonated

in the test circuit as follows:

1. With the SELECTOR in the USE position, connect the standard to one set of HI and GND binding posts on the Oscillator-Detector Unit.

NOTE: In order to avoid serious hand-capacitance effects, components with one terminal connected to a shield must be connected with the shield terminal to the grounded binding post.

2. Set the Resonating Capacitor switch to the High or Low position as required. The capacitance range is 45 to 570$\mu\mu$f in the High position and 30 to 45$\mu\mu$f in the Low position. Disconnect one end of the terminal strap (Figure 3) for Low position.

3. Position the HI Q — LO Q switch to the LO Q position. At some frequencies, low-C components of high Q may require that this switch be set to the HI Q position in order that the adjustment in step 10 may be made.

4. With the SELECTOR in the USE position and the INTENSITY control at maximum (full clockwise), adjust the CENTER Q control until the CRT trace is aligned with the —25% marking at the bottom of the Q scale.

5. Adjust the SET Q OF STD — COARSE control and the Resonating Capacitors (Figure 3) until a resonance curve is approximately centered on the CRT. (Actually, because of the slight nonlinearity of the sweep voltage, two resonance curves will be displayed.) Set the main resonating capacitor full counterclockwise, and tune through the entire capacitance range. Select the resonance occurring with the most capacitance. This will insure that the resonance curve

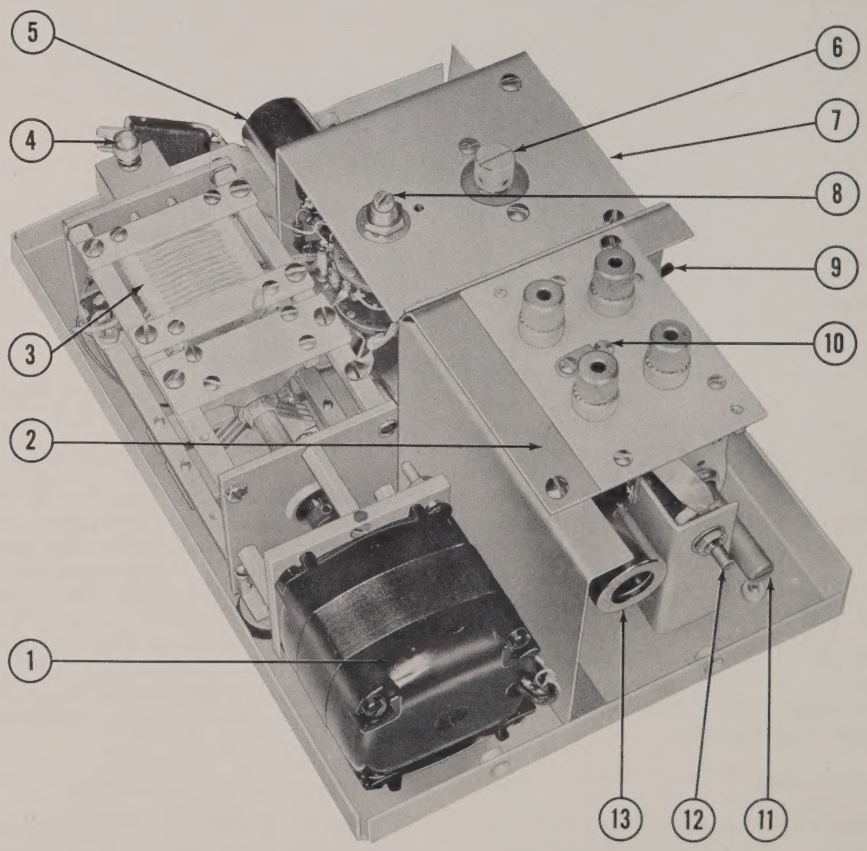


Figure 3. Oscillator — Detector Unit — Cover Removed

1. Rotating Capacitor Drive Motor
2. Detector Chassis
3. Rotating Sweep Capacitor
4. Rotating Capacitor Shaft Detent
5. Oscillator Tube, V101
6. SET Q OF STD — COARSE
7. Oscillator Chassis
8. FREQ RANGE
9. Motor Switch
10. High — Low Capacitance Switch
11. Resonating Capacitor, C122
12. Resonating Capacitor, C123
13. Detector Tube, V102

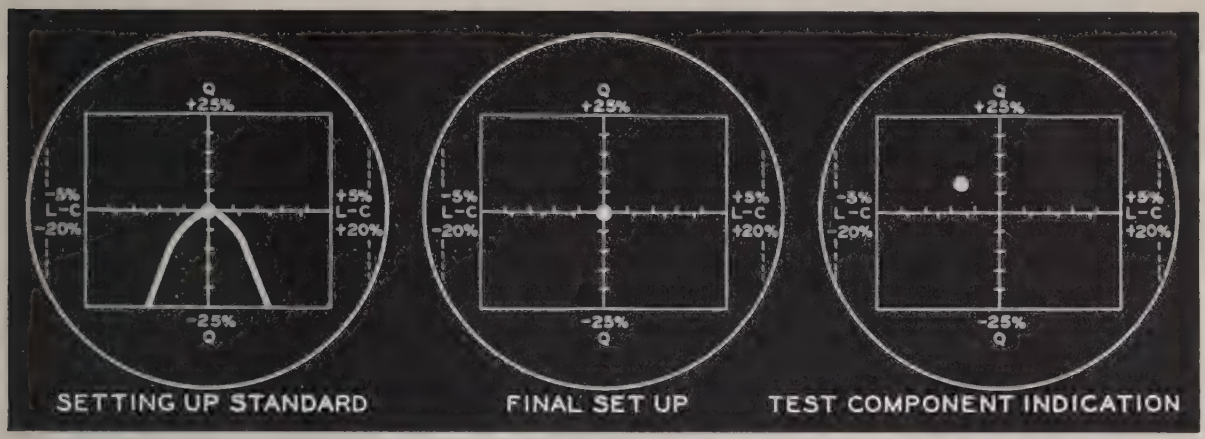


Figure 4. Set Up And Test Displays

displayed is a fundamental curve and not an unwanted harmonic of the oscillator.

6. Set the SELECTOR to the CENTER Q position and recenter the displayed trace.

7. Adjust the SET Q OF STD — COARSE control and the Resonatng Capacitors until the top of the resonance curve is displayed near the center of the CRT (0% Q and 0% L-C).

8. Turn the DOT POSITION control until a dot appears and is positioned at the peak of one of the resonance curves, then reduce the intensity with the INTENSITY control until the curves disappear and only the dot is visible.

9. Adjust the FOCUS and ASTIGMATISM controls until the dot is round and of sufficient intensity and minimum size.

10. With the SET Q OF STD — FINE control set at the center of its range, adjust the SET Q OF STD — COARSE control so that the dot is displayed as near as possible to the vertical center (0% Q) of the CRT. If a large adjustment is required, it may be necessary to retouch the resonating capacitor adjustment (step 7).

11. Adjust the SET Q OF STD—FINE control and refine the adjustment of the resonating capacitors so that the dot is positioned at the exact center (0% Q and 0% L-C) of the CRT.

NOTE: The resonating capacitor should be adjusted only while the standard is connected in the test circuit. Changing this adjustment during the component testing operation will invalidate the calibration of the Q Comparator.

12. Set the SELECTOR switch to the CENTER Q position, turn up the intensity, and recheck the CENTER Q adjustment.

13. Switch the SELECTOR to the CAL Q position, and recheck the CAL Q adjustment.

14. Switch the SELECTOR to the USE position and reduce the intensity. Refinement of the SET Q OF STD — FINE control and the Fine Resonating Capacitor control may be required if any adjustments were made in steps 12 or 13.

ESTABLISHING Q TOLERANCE LIMITS

In order to display Q instantaneously over a range of ±20% or ±5% in the reactance of the unknown, the frequency of the Q Comparator test signal is automatically and continuously varied. Thus —20% reactance corresponds to +12% frequency and +20% reactance is achieved by a deviation of —8.6% in frequency; the numbers being derived from the inverse square root relationship between capacitance and frequency. (See "Capacitance or Inductance and Frequency Relationship" in the Appendix.) For those components having a negligible variation of Q with frequency over the selected reactance sweep range, (1.0μh to 15mh and 500μμf to 0.01μf) the direct-reading calibration of the %Q and %L-C scales on the CRT is satisfactory.

In cases where the Q of a component varies rapidly with frequency and it is necessary to inspect to a close Q tolerance (±10% or better), variation in the expected Q of the standard over the selected reactance (frequency) range must be determined. This is necessary in order that the limits may be adjusted in line with the law of variation of the Q with frequency of the components under test. The preferred method for determining this variation is as follows:

1. Measure the Q of the standard component, against which the comparator is to be set up, at frequencies corresponding to the zero reactance and the desired limit reactance values. This should be done on a Type 260-A Q Meter.

2. From these measurements, calculate the percentage deviation of Q against frequency. (See the sample calculation in the Appendix under "Calculation of Percentage Deviation of Q Against Frequency".) If, for example, the standard has a Q which is 10% higher at minus 8.6% in frequency, the Q limit which corresponds to the +20% end of the reactance scale should be raised by 10%. A similar process would be followed at the minus reactance end of the scale.

3. Draw a grease pencil line on the reticule of the CRT to indicate the Q variation of the standard over the frequency (reactance) range as calculated in step 2. The line must pass through the origin

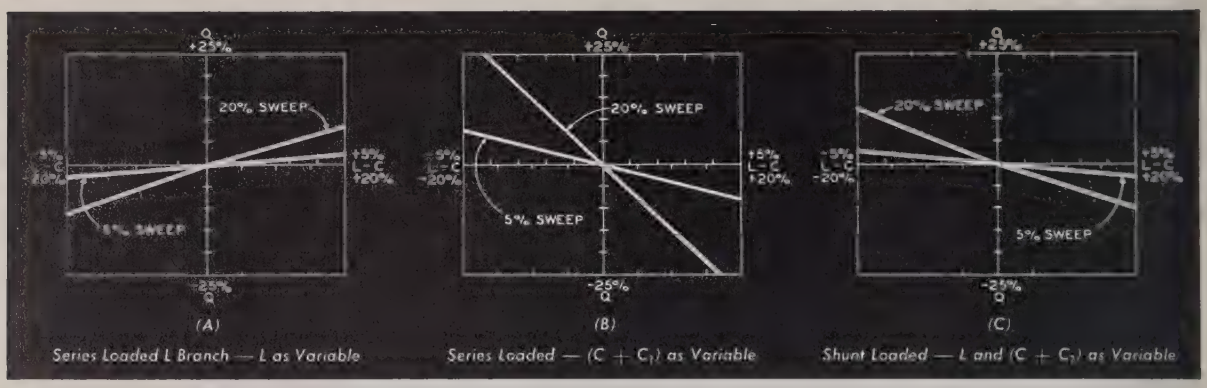


Figure 5. Variation Of Indicated Q With Varying Resonating Capacitance

of the coordinates (0% Q and 0% L-C) (Figure 12).

4. Draw two additional limit lines parallel to the line showing the performance of the standard and spaced from the standard line by the desired Q tolerance. These lines will pass through the desired Q tolerance on the vertical (% Q) axis.

NOTE: In many cases, typically those in which reactance sweeps of ±5% are used, the preceding procedure will be unnecessary, because the variation in Q of the standard over the reactance limits chosen is negligible compared to the Q limits to which the component is being inspected.

L-C TOLERANCE LIMITS

For coils of less than 1μh, the test circuit residual inductance of approximately 0.015μh deteriorates the accuracy of the direct reading L-C scale. For best accuracy, the following procedure is recommended.

1. Set up the components to the desired inductance limits in the Type 260-A Q Meter, correcting for the internal residual inductance of the Q Meter.

2. Adjust the L-C TRACE WIDTH and L-C TRACE POSITION controls so that these limit components read the desired tolerance.

For capacitors of less than 500$\mu\mu$f, the test circuit minimum capacitance of 30$\mu\mu$f will reduce the direct reading accuracy of the L-C scale. For best accuracy, a procedure similar to the one used for coils above is recommended.

TESTING PROCEDURE

After the initial set up procedure has been completed and the tolerance limits have been marked on the reticule of the CRT, disconnect the standard component from the test circuit binding posts and connect a test component in its place. The comparator may now be used as a simple "go—no-go" device. If the characteristics of the test component are such that a dot appears on the CRT within the marked tolerance limits, the component is considered acceptable. If the dot is displayed outside the marked limits, the test component is considered a reject. Further manipulation of controls or interpretation of results is unnecessary.

OPERATING PRECAUTIONS

The following precautionary operating notes should be observed to insure proper operation of the Q Comparator.

Test Circuit Resonating Capacitor

The test circuit resonating capacitor adjustment should not be disturbed during the component testing operation. Referring to the basic measuring circuit (Figure 6) and the basic equation of the measuring circuit, the reason for this is apparent. The equation states that

$$Q_{ind} = \left(\frac{C}{C + C_2}\right) Q.$$

Since C_2 appears in the denominator of the expression, and is a part of the constant of proportionality, it is obvious that an adjustment of C_2, other than in the initial set up procedure, (when the standard component is resonated in the test circuit) will upset the calibration of the instrument. This fact is stressed particularly for those users of previous BRC Q Meters and Q Comparators who have relied upon operator adjustment of the resonating capacitor to correct for and indicate reactance errors in the test component. In the 265-A Q Comparator, this information is directly available on the CRT and no readjustment of the resonating capacitor is necessary. Actually, it is not possible to determine the variation in Q versus frequency of a standard component by varying the resonating capacitance, since the Q calibration is a function of the resonating capacitor. Figure 5 shows the variation in indicated Q caused by varying the resonating capacitance in cases where either the equivalent series resistance or equivalent shunt resistance is constant. Note that in each case substantial errors occur with the ±20% reactance sweep, but that in the case of the constant shunt-loaded component the error is quite small (less than 5%) for the ±5% reactance sweep.

Recheck of Standard Display

For best operation, the Q Comparator should be checked for center position with the test standard at least once each hour during normal operation. If the half-hour warm up period is not used, the test standard should be checked at least twice in the first half

hour and again at the end of an hour. Occasional recheck of the L-C TRACE WIDTH setting is also desirable, especially if the oscillator frequency is changed.

APPLICATIONS

The following table lists some of the typical applications of the Q Comparator.

Components	Type Measurement
Coils	Tuning, inductance self resonance, C_d, and Q
Capacitors	Capacitance and loss factor
Resistors	Resistance, distributed L and C, and resonant frequency
Iron cores (powdered and feramic), shells, torroids, rods, and "E" type cores	Permiability
Networks	Q (within Q Meter range)
Quartz crystals	Capacitance of blanks and assemblies.
Vacuum tubes	Capacitances
Variable capacitance diodes	Capacitance and Q
Materials such as mica, silicon, etc.	Relative dielectric constant, loss factor, dielectric thickness, relative moisture absorbtion, and relative resistivity
RF, IF, and pulse transformers	Winding inductance and Q, mutual inductance and coupling coefficient, coupling and stray capacitance

SECTION III

THEORY OF OPERATION

BASIC OPERATING PRINCIPLE

The basic elements of the Q Comparator are shown in block diagram form in Figure 6. Test frequencies are generated by the oscillator which is tuned by an adjustable calibrated inductor. A motor-driven capacitor simultaneously sweeps the oscillator center frequency and generates a horizontal sweep voltage for the CRT display. The oscillator output is loop-coupled to a test circuit containing an adjustable capacitor connected across a test standard. When the test circuit is tuned to resonance by means of the adjustable capacitor, a resonance curve is detected, amplified, and displayed on the CRT. The resonance signal is also utilized for triggering a dot generator circuit to produce a dot at the peak of the displayed resonance curve.

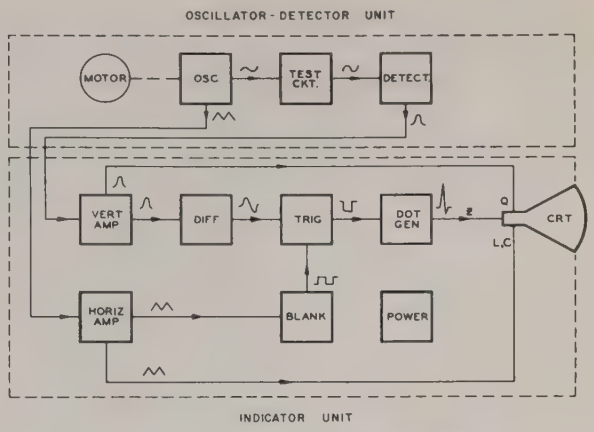


Figure 6. Basic Circuit Elements

The CRT display is adjusted so that the dot is positioned at the exact vertical and horizontal centers of the calibrated Q and L-C scales and the intensity is reduced so that only the dot appears on the CRT. The test standard is then removed from the test circuit and a test component is connected in its place. A difference in characteristics between the test component and the standard will be made immediately apparent by any displacement of the dot from the exact center of the CRT. This difference is directly readable on the CRT in plus or minus percent Q on the vertical axis, and plus or minus percent inductance and capacitance on the horizontal axis.

OSCILLATOR AND SWEEP GENERATOR

Except for the tuning technique, the oscillator is one of conventional design, consisting of a cross-connected 12AU7 double triode, V101, and operating in the 200-kc to 70-mc range. Center frequency tuning is accomplished by means of a variable inductor in the output tank circuit. Deviation is accomplished by means of a motor-driven capacitor. With this system, the ratio of capacitance variation to the total average capacitance is independent of the coils used, and the same relative reactance can be obtained for any center frequency.

The oscillator output is coupled by means of a loop to the injection impedance of the test circuit detector. Amplitude is controlled by varying the oscillator tube plate voltage.

Simultaneously with providing a swept frequency, one section of the motor-driven capacitor generates a triangular voltage for the horizontal sweep (corresponding to the X axis on the CRT) which is always in synchronism with the instantaneous frequency deviation.

TEST CIRCUIT

The simplified equivalent circuit of the Q measuring circuit and injection circuit of the 265-A Q Comparator is shown in Figure 7. Note that the injection is introduced in shunt with the tuned circuit by means of the differential capacitor. This method of injection is a departure from the conventional "series injection" system used in BRC Q Meters. While there is no fundamental advantage of one method over the other, it will be shown that there are differences of behavior between the 265-A and previous BRC Q Meters which are directly attributable to the different injection methods.

A further simplification of the Q circuit and injection circuit is shown in Figures 8 and 9. Figure 8 is the constant voltage equivalent circuit based on a constant voltage generator, E, while Figure 9 is the constant current equivalent circuit. In order to simplify the mathematical explanation, the constant current equivalent circuit of Figure 9 will be used. The constant current generator, I, has an output equal to EωC. Following the Norton's Theorem transformation, the equivalent insertion capacitance, C, shown in series with the generator and tuned cir-

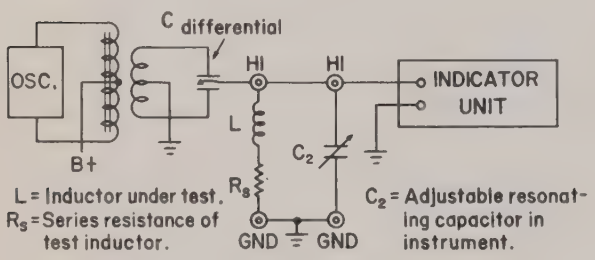


Figure 7. Q Measuring Equivalent Circuit

cuit in Figure 8, now appears in shunt with the current generator and the tuned circuit. This is important to the understanding of the circuit action. Also, resistor R_g of Figure 8 is omitted in the transformation to the constant current generator since it is a negligible impedance considering the available values of C.

Resonance in Figure 8 is defined as the resonance of $C + C_2$ as an equivalent capacitor with L, or

$$\omega = \frac{1}{\sqrt{L\,(C + C_2)}} .$$

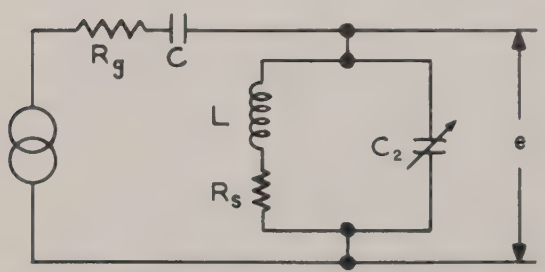


Figure 8. Constant Voltage Equivalent Circuit

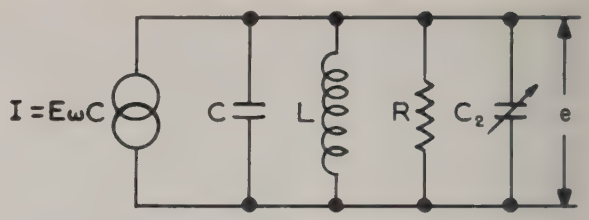


Figure 9. Constant Current Equivalent Circuit

Under these conditions, the circuit of Figure 9 may be re-drawn as shown in Figure 10 where e, the drop across the shunt resistance at resonance of the tuned circuit, is equal to EωCR or $e/E = \omega CR$.

A reasonable approximation for Q's greater than 10 is $Q = \omega\,(C + C_2)R$ or $R = Q/\omega(C + C_2)$. Substituting R in this expression for R in the equation $e/E = \omega CR$, we have

$$e/E = \frac{\omega CQ}{\omega\,(C + C_2)} .$$

Cancelling yields the relationship

$$e/E = \left(\frac{C}{C + C_2}\right)Q,$$

which is the basic equation of the "shunt injection" Q measuring circuit.

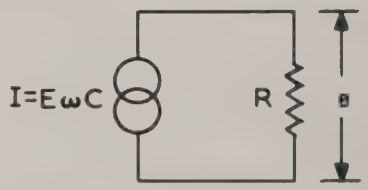


Figure 10.

It is obvious from the foregoing, that certain sweeping simplifications have been made. This is justified by the careful design of the Q measuring circuit itself. For example, the neglect of R_g in Figure 9 is justified by the fact that the equivalent R_g, which is the source resistance of the constant voltage generator in Figure 8, is an extremely low resistance compared to the equivalent series reactance of the differential capacitor. In addition, the input impedance of the detector circuit has been designed to be quite high compared to normal shunt impedances to be expected in the measuring circuit.

As is true in BRC Q Meters, the input impedance of the detector is a limitation to the maximum shunt impedance which can be measured at the extremely low and extremely high frequency ends of the frequency range. This fact is of less importance in the comparator than in a Q Meter, however, since the interest here is in comparing an unknown with a standard. Absolute accuracy is not as important as the accuracy with which unknowns may be compared with a standard.

Since the range of comparison is reasonably small

(less than ±25%), the effects of incidental shunt resistances on the Q circuit are greatly minimized. The input resistance of the detector may be considered lumped with the shunt losses of the Q circuit tuning capacitor. This equivalent resistance is approximately 35 megohms at 200 kc, dropping to 100 kilohms at 70 mc. The stated accuracy of the instrument takes into account the effects of the shunt losses mentioned along with the series resistance losses of the Q capacitor and the terminals.

DETECTOR

The detector (½ of V102), which is connected in shunt with the high post of the Q measuring circuit, is designed to respond to the instantaneous resonance curve being traced by the sweeping frequency and to present a very high input impedance. The circuit chosen permits the highest product of input impedance and sensitivity that is reasonably convenient. The other section of V102 is used as a means of balancing the average dc component that appears in the cathode of the input section.

Instantaneous voltage differences between the referenced cathode and active cathode are recognized by subsequent circuitry in the Indicating Unit and a spot of light is produced at the peak of the resonance curve. The time constant in the cathode of the active section of the detector is chosen to provide the maximum of input impedance, consistent with good transient response of the circuit. These factors result in the choice of a time constant which is a little too long to permit a faithful tracing of the entire resonance curve, providing some departure from true slope on the discharge or trailing side of the resonance curve. This is a necessary compromise in order to permit the spot to fall at or near the top of the resonance curve over the width of the calibrated trace.

VERTICAL AMPLIFIERS

Two differential dc amplifiers, V210 and V211, provide the dc amplification which is required to keep the base line (corresponding to a no-input signal) in place so that the height of the resonance curve can be measured from this base for any position or width of the resonance peak. The differential amplifiers provide a simple means for balancing level variations caused by heater voltage changes, and for depressing the base line so that only the peaks of the resonance curves are visible on the CRT.

A voltage divider network, stabilized with a neon lamp, V209, provides a means for setting up and checking the vertical amplification at the input of the vertical amplifier. The amplification of the vertical channel can be adjusted by varying the amount of negative feedback in the first stage. The vertical amplifier also delivers the input signal to the differentiator stage.

DIFFERENTIATOR AND TRIGGER

The differentiator-trigger circuit, consisting of a feedback pentode differentiator, ½ of V205, between two cathode followers, V204 and ½ of V205, provides a trigger pulse for the dot generator at the precise moment of the resonance curve peak. The differentiator produces first and second derivatives of the resonance curve which, in turn, are used to anticipate the peak of the resonance curve to allow for circuit delays.

In addition to acting as a source of feedback voltage to the differentiator proper, the second cathode follower drives the input amplifier to the trigger circuit. A minimum number of coupling capacitors have been used in the circuit in order to keep down any charging effects.

The modified "Schmitt" trigger circuit, V207, is essentially an overdriven amplifier circuit delivering a well-defined voltage step of constant amplitude at the moment the input voltage reaches a predetermined level.

DOT GENERATOR

The step voltage from the trigger is differentiated and serves to initiate the final brightening pulse which is generated in a monostable multivibrator, V208. In order to obtain a pulse of high amplitude and very short duration without excessive power consumption, high value load resistors are used and feedback and coupling capacitors of the multivibrator consist of the distributed and tube capacitances.

HORIZONTAL AMPLIFIERS

A small triangular voltage, obtained from an RC network containing the rotating capacitor, is amplified to a sufficient level to cover the entire CRT. Filters isolate the generation of this voltage from the oscillator. The first two stages of the horizontal amplifiers, V201, are conventional RC-coupled triodes, with time constants that prevent the triangle from deteriorating in shape. The final amplifier stage, V202, is a differential amplifier which provides a push-pull output and an easy means for centering the trace on the CRT.

One of the triangular outputs is coupled to a blanking circuit, V203. Blanking is necessary because the slight nonlinearity of the sweep voltage produces two resonance peaks on the CRT. The blanking circuit eliminates the brightened dot from one of these peaks, so that a single dot appears on the CRT.

CATHODE-RAY TUBE

A type 5ABP1 cathode-ray tube is used as the display element. The tube is operated with its cathode at −1700 volts, the deflection system at a few hundred volts positive, and the post accelerator at +1700 volts. An astigmatism control is included in addition to the usual focus and brightness controls, in order to provide a brightened dot that is reasonably small and circular. The dot is considerably brighter than the normal line display.

POWER SUPPLY

The power supply furnishes all of the voltages required by the Q Comparator. Certain of these voltage lines are stabilized with voltage regulator tubes because they feed stages sensitive to dc level

changes. Tubes with high permissible heater-cathode voltage ratings have been employed in cases where cathodes are operated near 150 volts; eliminating the need for separate filament windings. Because of the number of tubes used, some drawing relatively heavy currents during short intervals (pulses), thorough filtering is employed in the power supply in addition to sectionwise decoupling.

SECTION IV

MAINTENANCE AND TROUBLE SHOOTING

GENERAL

The Q Comparator has been carefully calibrated prior to shipment from the factory and should not normally require servicing until tubes have aged beyond their useful life. Any of the tubes may be replaced with commercially available tubes. Though it may not be necessary in all instances, it is recommended that the set up procedure given in Section II be performed after each tube change to insure proper operation of the instrument. If the detector tube, V102, or the vertical amplifier tube, V210, is changed, the balance adjustment, given in this Section, should also be checked. Replacement of any of the Power Supply tubes should be followed by a check of the power supply adjustment given below.

POWER SUPPLY ADJUSTMENT

Connect the Q Comparator to the voltage source through a voltage regulator. With a milliameter connected in series with V302 and V303, adjust resistor R322 until the milliameter indicates 5 milliampers with the input voltage set to 105 volts. Adjust R320 in the same manner with the milliameter connected in series with V304. The slide resistors are located in the Power Supply on a terminal board mounted directly behind the Indicator Unit front panel. R320 is mounted on the outside end of the board.

BALANCE ADJUSTMENT

Disconnect the standard or test component from the Oscillator-Detector Unit binding posts and remove the Indicator Unit cover. Switch the SELECTOR to the USE position and short out the Oscillator-Detector Unit test terminals. Using a VTVM, measure the voltage at the grids (pins 2 and 7) of V210. The voltage at these points should be the same, within ± 0.1 volt. Adjust by means of the Balance control located directly below the detector tube, V102.

TROUBLE SHOOTING

Data, including a socket voltage chart, a trouble-shooting chart giving some of the more common troubles that might be encountered, and a schematic diagram, have been included as an aid to trouble shooting. Idealized waveforms obtainable with an oscilloscope at the input and output of all stages, under normal operating conditions, have been included on the schematic diagram, Figure 13.

It will be found that most cases of malfunctioning of the Q Comparator will be the result of tube failure. For this reason, it is recommended that one of the first steps in the trouble-shooting procedure consist of an inspection of the tubes for lighted filaments. If all filaments are lighted and the trouble indicates faulty operation of a specific circuit or stage, the tubes in this circuit or stage should be checked in a tube tester before further steps are taken.

SOCKET VOLTAGES

The voltages given in the Socket Voltage Chart were measured under normal line voltage conditions of 115 volts ac, with a Type 520A-6 Oscillator Inductor plugged into the oscillator circuit, a Type 103-A21 Inductor connected across the test circuit terminals, and the oscillator and test circuits adjusted for 1-megacycle operation. All voltages are positive dc unless otherwise specified.

Equipment Used For Measurements

DC voltages, except the high voltages at the CRT socket and anode, were measured with a Hewlett-Packard 310B VTVM. DC voltages at pins 1, 2, 3, and 14, and the voltage at the anode cap of the CRT were measured with a Simpson Model 260 VOM. AC filament voltages were measured with a Ballantine voltmeter. Voltages at pins of V101 and V102 were measured using a Vector socket.

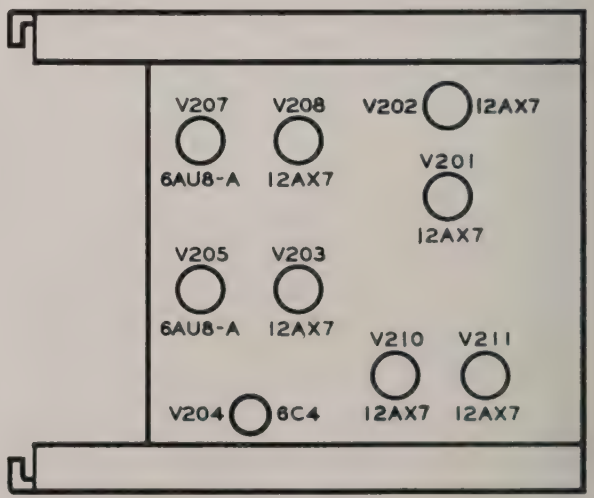
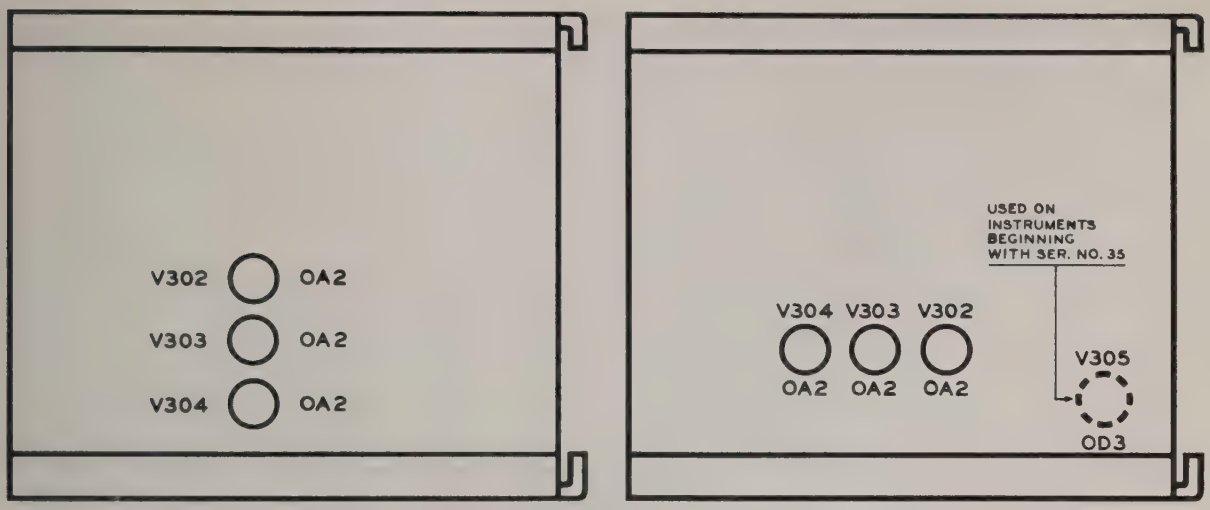


Figure 11. Tube Layout — Deflection And Dot Generator Chassis



(A)
Early Production Models

(B)
Current Production Models

Figure 12. Tube Layout — Power Supply Chassis

SOCKET VOLTAGE CHART

Circuit Symbol	*Tube Type*	*Pin Numbers*														
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*Cap*
V101	12AU7A	110	—56	0	6.3 vac	6.3 vac	110	—50	0	6.3 vac						
V102	12AU7A	275	0	18	6.3 vac	6.3 vac	275	0	18	6.3 vac						
V201	12AX7	190	0	1.75	6.3 vac	6.3 vac	175	0	1.65	6.3 vac						
V202	12AX7	200	—8.2	—6.2	6.3 vac	6.3 vac	205	—8.3	—6.4	6.3 vac						
V203	12AX7	—87	—140	—140	6.3 vac	6.3 vac	—37	—87	—74	6.3 vac						
V204	6C4	285	NC	6.3 vac	6.3 vac	285	155	165								
V205	6AU8A	100	100	145	6.3 vac	6.3 vac	—25	—105	145	160						
V207	6AU8A	100	100	145	6.3 vac	6.3 vac	100	95	145	145						
V208	12AX7	340	—36	6.6	6.3 vac	6.3 vac	100	7.8	6.6	6.3 vac						
V210	12AX7	160	18	19	6.3 vac	6.3 vac	155	18	19	6.3 vac						
V211	12AX7	155	38	38	6.3 vac	6.3 vac	270	30	32	6.3 vac						
V302	OA2	NC	NC	NC	NC	290	NC	145								
V303	OA2	NC	NC	NC	NC	145	NC	0								
V304	OA2	NC	NC	NC	NC	0	NC	145								
V305	OD3	NC	0	NC	NC	145	NC	NC	NC							
V301	5ABP1	—1450	—1450	—1500	NC	—960	NC	155	270	210	205	205	NC	NC	—1450	+1600

Control Settings

Control settings during the voltage measurements were as follows:

Control	*Setting*
SELECTOR Switch	USE
HI Q — LO Q Switch	LO Q
LC TRACE WIDTH	±20% trace
Oscillator Inductor Tuning	1-megacycle
Resonating Capacitors	Adjusted for 1-megacycle resonance

TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
1. With the power turned on, the pilot lamp lights but the capacitor motor does not run.	Motor switch turned off or defective. Defective starting capacitor, C101.	Turn on or replace switch. Replace capacitor.
2. No CRT display in all SELECTOR switch positions.	Defective regulator tube, V302, V303, V304, or V305. Defective tube V204, V207, V210, or V211. Open secondary winding in transformer, T301. Defective rectifier, CR301 through CR306. Defective choke, L301. Defective cathode-ray tube.	Replace tube. Replace tube. Replace transformer. Replace rectifier. Replace choke. Replace tube.
3. CAL Q and CENTER Q controls are inoperative.	Defective tube V210 or V211. Open resistor in V210 or V211 tube stage.	Replace tube. Replace resistor.
4. L-C TRACE WIDTH and L-C TRACE POSITION controls are inoperative.	Defective tube, V202. Defective resistor or capacitor in V202 stage.	Replace tube. Replace defective component.
5. L-C TRACE POSITION control is operative but the L-C TRACE WIDTH control is inoperative.	Defective tube, V201. Defective choke, L102. Defective resistor or capacitor in V201 stage.	Replace tube. Replace choke. Replace defective component.
6. Comparator functions properly with SELECTOR switch in CAL Q and CENTER Q positions but there is no resonance display in USE position.	FREQ. RANGE switch or HI-LO CAP switch positioned incorrectly or open. Defective tube, V101 or V102. Defective resistor or capacitor in V101 or V102 stage. Open switch, S201. Standard or test component will not resonate in oscillator coil frequency range.	Set switches correctly or repair open. Replace tube. Replace defective component. Repair or replace switch. Select different oscillator coil.
7. No dot displayed on CRT.	Defective tube, V204, V205, V207, or V208. Defective resistor or capacitor in one of above tube stages.	Replace tube. Replace defective component.
8. Two dots displayed on CRT.	Defective tube, V203. Defective resistor or capacitor in V203 tube stage. Stator of sweep capacitor C116B not aligned properly.	Replace tube. Replace defective component. With the L-C TRACE WIDTH control set to ±5% and the INTENSITY control set at maximum, adjust the FOCUS control to obtain the sharpest resonance curve (not dot) possible. Loosen the upper stator mounting screws for sweep capacitor C116B (large section) until they are friction tight, then reposition the stator slightly until the resonance curves on the CRT are superimposed or are within 1/32 inch of each other.
9. Dot "jitters" vertically.	Loose connection at test terminals or in test circuit. Defective tube V206, V209, V302, V303, V304, or V305. Defective Type 520-A Inductor.	Repair connection. Replace tube. Replace inductor.
10. Dot "jitters" horizontally.	Sweep capacitor out of synchronization with 60 cycles due to friction in bearings.	Loosen sweep capacitor drive motor mounting screws slightly and realign capacitor end plates, while observing CRT display, by repositioning motor. Tighten mounting screws.
11. Dot moves or drifts horizontally — trace position fixed.	Defective tube, V101. Defective component in V101 oscillator circuit.	Replace tube. Replace defective component.
12. Dot and trace move or drift horizontally.	Defective tube, V201 or V202. Defective resistor or capacitor in one of above tube stages.	Replace tube. Replace defective component.
13. Base line will not depress and is visible on the CRT with the SELECTOR in USE position.	Balance control out of adjustment. Defective tube, V102.	Readjust Balance control, R112. See Balance Adjustment in Sectoin IV. Replace tube and readjust Balance Control.

SECTION V

REPLACEABLE ELECTRICAL PARTS

GENERAL

The following list contains all of the electrical parts used in the Type 265-A Q Comparator which may be replaced in the field. Manufacturer's type numbers have been included for all standard parts. If the "Mfg." and "Mfg's. Type No." columns have been left blank, the item is a nonstandard part obtainable from BRC stock only. A list of manufacturer abbreviations used in the parts list is given below.

LIST OF MANUFACTURERS

Abbreviation	Manufacturer's Name
AB	Allen-Bradley Co.
AER	Aerovox Corp.
AH	Arrow-Hart and Hegeman Electric Co.
AST	Astron Corp.
CD	Cornell-Dublier Electric Corp.
CEP	Cherry Electric Products Corp.
CL	Clarostat Mfg. Co., Inc.
CRL	Centralab, A Div. of Globe-Union, Inc.
EMM	Electro-Motive Mfg. Co.
ERC	Erie Resistor Corp.
FRC	Freed Radio Corp.
GA	Good-All Electric Mfg. Co.
GE	General Electric Co.
HBJ	Howard B. Jones Co.
IRC	International Resistance Co.
JON	E. F. Johnson Co.
LEC	Lectrohm, Inc.
LTF	Littlefuse, Inc.
MAL	P. R. Mallory & Co., Inc.
ME	Micamold Electronics
MEPCO	Mepco, Inc.
OAK	Oak Mfg. Co.
RPC	Resistance Products Co.
SLE	Sylvania Electric Products, Inc.
SPR	Sprague Electric Co.
ST	Sarkes Tarzian, Inc.
TM	Thordson-Meissner Co.
WAL	Ward Leonard Electric Co.
WKP	Wilkor Products Inc.

TYPE 265-A Q COMPARATOR ELECTRICAL COMPONENTS PARTS LIST

Circuit Symbol	Value	Description	BRC Part No.	Mfg.	Mfg's. Type No.
B101		Motor: 115vac, 60Ω, 1/1500hp, 1800rpm, 4 pole synchronous	306114		
C101	1.15μf	Capacitor, Fixed: ±10%, 220v, paper	83122	CD	1776
C102,103	47μμf	Capacitor, Fixed: ±2%, 500wvdc, ceramic	82115	CRL	TCZ
C104	0.01μf	Capacitor, Fixed: +80% −20%, 600wvdc, ceramic	82428	CRL	DAO
C105	2.7-10.8μμf	Capacitor, Variable: butterfly, air di-electric	84091	JON	11MB11
C106-109	0.001μf	Capacitor, Fixed: +80% −20%, 600wvdc, ceramic	82306	CRL	DA
C110	8μf	Capacitor, Fixed: −10 +50%, 450wvdc, electrolytic	83028	AER	PRS-EP
C112	47μμf	Capacitor, Fixed: ±2%, 500wvdc, ceramic	82115	CRL	TCZ
C114,115	0.005μf	Capacitor, Fixed: +80% −20%, 600wvdc, ceramic	82034	CRL	DD502
C116A,B		Capacitor, Variable: motor driven	305353		
C117	0.033μf	Capacitor, Fixed: ±10%, 400wvdc, paper	82430	CD	PM
C118,119	0.005μf	Capacitor, Fixed: +80% −20%, 600wvdc, ceramic	82034	CRL	DD502
C120	4.5-25μμf	Capacitor, Variable: 600wvdc, NPO, ceramic	84005	CRL	822-AZ
C121	1.5-7μμf	Capacitor, Variable: 500wvdc, NPO, ceramic	84066	ERC	T52A
C122	2.7-19.6μμf	Capacitor, Variable: air dielectric	84084	JON	160-110
R110	22KΩ	Resistor, Fixed: ±5%, ½w, Comp.	80472	AB	EB
R111	15KΩ	Resistor, Fixed: ±5%, ½w, Comp.	80336	AB	EB
R112	25KΩ	Resistor, Variable: ±10%, 2w, Comp.	81028	AB	JL

TYPE 265-A Q COMPARATOR ELECTRICAL COMPONENTS PARTS LIST (Continued)

Circuit Symbol	Value	Description	BRC Part No.	Mfg.	Mfg's. Type No.
R113	100Ω	Resistor, Fixed: ±5%, ½w, Comp.	80062	AB	EB
R114,115	220Ω	Resistor, Fixed: ±5%, ½w, Comp.	80188	AB	EB
R116	100Ω	Resistor, Fixed: ±5%, ½w, Comp.	80062	AB	EB
R117	8KΩ	Resistor, Fixed: ±5%, 10w, ww (Used on Q Comparators Serial Numbers 10 to 34 only.)	80349	SPR	456E8R
R118	100KΩ	Resistor, Fixed: ±5%, ½w, Comp. (Used on Q Comparators beginning with Serial Number 35.)	80517	AB	EB
S101		Switch, Toggle: DPDT, 125v, 5a	88059	AH	81027CE
S102		Switch, Rotary: 2 section, 2 position	305679	OAK	F
S104		Switch: SPDT (Used on Q Comparators Serial Numbers 10 to 34 only.)	306266	CEP	S30-97A
V101,102		Tube, Electron: 12AU7-A			
C201	0.5μf	Capacitor, Fixed ±10%, 400wvdc, paper	83115	GA	663UW
C202	0.01μf	Capacitor, Fixed: +80% −20%, 600wvdc, ceramic	82428	CRL	DAO
C203	3300μμf	Capacitor, Fixed: ±5%, 500wvdc, mica	82323	EMM	CM30B
C204	100μμf	Capacitor, Fixed: ±20%, 250wvdc, ceramic	82120	ERC	GPIK-101
C205	0.5μf	Capacitor, Fixed: ±10%, 400wvdc, paper	83115	GA	663UW
C206	100μμf	Capacitor, Fixed: ±20%, 350wvdc, ceramic	82120	ERC	GPIK-101
C207,208	0.5μf	Capacitor, Fixed: ±10%, 400wvdc, paper	83115	GA	663UW
C209	0.01μf	Capacitor,Fixed: +80%—20%, 600wvdc, ceramic	82428	CRL	DAO
C210	330μμf	Capacitor, Fixed: ±5%, 500wvdc, mica	82217	EMM	CM15-605
C211	1μf	Capacitor, Fixed: +30%—20%, 200wvdc, paper	83101	AST	ML-2-1M
C212	0.01μf	Capacitor,Fixed: +80%—20%, 600wvdc, ceramic	82428	CRL	DAO
C213	0.02μf	Capacitor, Fixed: ±10%, 600wvdc, disc	83118	ERC	ED
C214	1μf	Capacitor, Fixed: +30%—20%, 200wvdc, paper	83101	AST	ML-2-1M
C215	0.01μf	Capacitor,Fixed: +80%—20%, 600wvdc, ceramic	82428	CRL	DAO
C216	100μμf	Capacitor, Fixed: ±20%, 350wvdc, ceramic	82120	ERC	GPIK-101
C217	0.1μf	Capacitor, Fixed: ±10%, 400wvdc, paper	83001	ME	345BL21
C218	200μμf	Capacitor, Fixed: ±5%, 500wvdc, mica	82215	EMM	CM20B
C219	100μμf	Capacitor, Fixed: ±20%, 350wvdc, ceramic	82120	ERC	GPIK-101
C220	220μμf	Capacitor, Fixed: ±2.5%, Ceramicon	82219	ERC	GP
C301A,B,C	10-10-10μf	Capacitor, Fixed: −10+50%, 450wvdc, dry electrolytic	83050	MAL	FP
C302	500μμf	Capacitor, Fixed: ±20%, 2500wvdc, ceramic disc	82241	GA	500-GMV-3KV
C303,304	0.1μf	Capacitor, Fixed: ±10%, 400wvdc, paper	83001	ME	345BL21
C305,306	0.1μf	Capacitor, Fixed: +20%—10%, 2000wvdc, paper	83113	AER	AFH1-25
C307	0.01μf	Capacitor,Fixed: +80%—20%, 600wvdc, ceramic	82428	CRL	DAO
C308A,B	40-40μf	Capacitor, Fixed: −10+50%, 450wvdc, electrolytic	83120	MAL	FP
C309,310	40μf	Capacitor, Fixed: −10+50%, 450wvdc, electrolytic	83102	AST	E
C311,312	0.1μf	Capacitor, Fixed: ±10%, 400wvdc, paper	83001	ME	345BL21
C313	40μf	Capacitor, Fixed: −10%+100%, 200wvdc, electrolytic	83112	AER	AFH1-25
C314	0.1μf	Capacitor, Fixed: ±10%, 400wvdc, paper	83001	ME	345BL21
CR301,302		Rectifier, Selenium	305604	ST	026-100H-Q
CR303-306		Rectifier, Silicon: 130vac	305590	ST	M-150
F301		Fuse: 1a, 250v, SLO BLO	95012	LTF	3AG
I301		Lamp: 6-8v, 0.15a	90904	GE	47

TYPE 265-A Q COMPARATOR ELECTRICAL COMPONENTS PARTS LIST (Continued)

Circuit Symbol	Value	Description	BRC Part No.	Mfg.	Mfg's. Type No.
J101		Connector, Receptacle: 12 contact	303566	HBJ	S-312-AB
L301	10h	Choke, Filter: 80ma, iron core	85402	FRC	11454
P301		Power Cord Assembly	01019	GE	S1-53016
R201	1.5megΩ	Resistor, Fixed: ±10%, ½w, Comp.	80632	AB	EB
R202	10megΩ	Resistor, Fixed: ±10%, ½w, Comp.	80682	AB	EB
R203	150kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80564	AB	EB
R204	1megΩ	Resistor, Fixed: ±10%, ½w, Comp.	80655	AB	EB
R205	6.8kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80387	AB	EB
R206	100kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80517	AB	EB
R207	220kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80555	AB	EB
R208	6.8kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80387	AB	EB
R209	1megΩ	Resistor, Variable: w/rotary switch, ±10% ½w	81515	CRL	30
R210	3.3megΩ	Resistor, Fixed: ±5%, ½w, Comp.	80644	AB	EB
R211	1.5megΩ	Resistor, Fixed: ±10%, ½w, Comp.	80632	AB	EB
R212,213	220kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80555	AB	EB
R214	10kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80361	AB	EB
R215	180kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80558	AB	EB
R216	10kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80361	AB	EB
R217	1megΩ	Resistor, Fixed: ±10%, ½w, Comp.	80655	AB	EB
R218	500kΩ	Resistor, Variable: ±10%, 2w, Comp.	81606	AB	J
R219	470kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80640	AB	EB
R220	1megΩ	Resistor, Fixed: ±10%, ½w, Comp.	80655	AB	EB
R221	6.8kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80549	AB	EB
R222	120kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80550	AB	EB
R223	330kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80651	AB	EB
R224	100kΩ	Resistor, Fixed: ±5%, 1w, Comp.	80521	AB	GB
R225	10kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80361	AB	EB
R226	150kΩ	Resistor, Fixed: ±5%, 1w, Comp.	80528	AB	GB
R227	100kΩ	Resistor, Fixed: ±5%, 1w, Comp.	80521	AB	GB
R228	220kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80555	AB	EB
R229	470kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80640	AB	EB
R230	100kΩ	Resistor, Fixed: ±5%, 1w, Comp.	80521	AB	GB
R231	330kΩ	Resistor, Fixed: ±5%, 1w, Comp.	80647	AB	GB
R232	68kΩ	Resistor, Fixed: ±5%, 1w, Comp.	80552	AB	GB
R233	82kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80554	AB	EB
R234	500kΩ	Resistor, Variable: ±10%, 2w, Comp.	81606	AB	J
R235	150kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80564	AB	EB
R236	1.2kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80201	AB	EB
R237	100kΩ	Resistor, Fixed: ±5%, 1w, Comp.	80521	AB	GB
R238	47kΩ	Resistor, Fixed: ±5%, 1w, Comp.	80470	AB	GB
R239	68kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80549	AB	EB
R240	100kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80517	AB	EB
R241	560kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80629	AB	EB
R242	20kΩ	Resistor, Fixed: ±1%, ½w, film	80344	WKP	CP
R243	10kΩ	Resistor, Fixed: ±1%, ½w, film	80346	IRC	DCC
R244	470kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80640	AB	EB
R245	680kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80663	AB	EB
R246	150kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80564	AB	EB
R247	220kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80555	AB	EB
R248	15kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80336	AB	EB
R249	33kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80461	AB	EB
R250	15kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80336	AB	EB
R251	120kΩ	Resistor, Fixed: ±5%, 1w, Comp.	80525	AB	GB
R252	680kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80663	AB	EB

TYPE 265-A Q COMPARATOR ELECTRICAL COMPONENTS PARTS LIST (Continued)

Circuit Symbol	Value	Description	BRC Part No.	Mfg.	Mfg's. Type No.
R253	1megΩ	Resistor, Fixed: ±10%, ½w, Comp.	80655	AB	EB
R254,255	180kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80558	AB	EB
R256	220kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80555	AB	EB
R257	50kΩ	Resistor, Variable: ±10%, 2w, Comp.	81401	AB	J
R258	220kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80555	AB	EB
R259	500kΩ	Resistor, Variable: ±10%, 2w, Comp.	81606	AB	J
R260	1.5megΩ	Resistor, Fixed: ±10%, ½w, Comp.	80632	AB	EB
R261	2.2megΩ	Resistor, Fixed: ±5%, ½w, Comp.	80649	AB	EB
R262	100Ω	Resistor, Fixed: ±10%, ½w, Comp.	80716	AB	EB
R263	460kΩ	Resistor, Fixed: ±1%, ½w, film	80584	MEPCO	C-15
R264	1.556megΩ	Resistor, Fixed: ±1%, ½w, film	80635	MEPCO	C-15
R265	5.6megΩ	Resistor, Fixed: ±5%, ½w, Comp.	80636	AB	EB
R266	100Ω	Resistor, Fixed: ±10%, ½w, Comp.	80716	AB	EB
R267	68kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80549	AB	EB
R268	180kΩ	Resistor, Fixed: ±5%, ½w, Comp. (Used on instruments beginning with Serial No. 35)	80558	AB	EB
R302	47kΩ	Resistor, Fixed: ±5%, 2w, Comp.	80494	AB	HB
R303	1kΩ	Resistor, Fixed: ±5%, 2w, Comp.	80151	AB	HB
R304	39kΩ	Resistor, Fixed: ±5%, 2w, Comp.	80424	AB	HB
R305	2kΩ	Resistor, Variable: ±10%, 4w, ww	81218	CL	10
R306	22kΩ	Resistor, Fixed: ±5%, 1w, Comp.	80404	AB	GB
R307	120kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80550	AB	EB
R308	470kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80640	AB	EB
R309	330kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80651	AB	EB
R310	500kΩ	Resistor, Variable: ±10%, 2w, Comp.	81606	AB	J
R311	150kΩ	Resistor, Fixed: ±5%, ½w, Comp.	80564	AB	EB
R312	1megΩ	Resistor, Fixed: ±10%, ½w, Comp.	80655	AB	EB
R313	2.5megΩ	Resistor, Variable: ±10%, 2w, Comp.	81072	AB	J
R314,315	2.7megΩ	Resistor, Fixed: ±10%, ½w, Comp.	80634	AB	EB
R316A,B	20megΩ	Resistor, Fixed: ±5% at dc, 2w, Comp.	80684	AB	HB
R316C	10megΩ	Resistor, Fixed: ±5% at dc, 2w, Comp.	80683	AB	HB
R317,318	150kΩ	Resistor, Fixed: ±5%, 2w, Comp.	80529	AB	HB
R319	500Ω	Resistor, Fixed: ±5%, 5w, ww	80729	WAL	5F500
R320	5kΩ	Resistor, Adjustable: ±10%, 10w, ww	80297	WAL	10A5000
R321	500kΩ	Resistor, Variable: ±10%, 2w, Comp.	81606	AB	J
R322	3kΩ	Resistor, Adjustable: +10%—5%, 10w, ww	80296	WAL	10A3000
R323	27kΩ	Resistor, Fixed: ±5%, 2w, Comp.	80468	AB	HB
R324	470Ω	Resistor, Fixed: ±5%, 2w, Comp.	80123	AB	HB
R325	1kΩ	Resistor, Fixed: ±5%, 2w, Comp.	80151	AB	HB
R326	150Ω	Resistor, Fixed: ±5%, 20w, ww	80090	LEC	2R
R327	6kΩ	Resistor, Fixed: 10w, ww (Used on Q Comparators beginning with Serial Number 35.)	80299	SPR	456E
S201		Switch, Rotary: 1 section, 3 position	305681		
S202		Switch, Rotary: w/variable resistor R209	81515	CRL	30
S301,302		Switch, Toggle: DPDT, 125v, 5a	88059	AH	81027CE
T301		Transformer, Power	305373		
V201-203		Tube, Electron: 12AX7			
V204		Tube, Electron: 6C4			
V205		Tube, Electron: 6AU8-A			
V206		Lamp, Glow: 65vac, ½w, NE-2			
V207		Tube, Electron: 6AU8-A			
V208		Tube, Electron: 12AX7			
V209		Lamp, Glow: 65vac, ½w, NE-2			
V210,211		Tube, Electron: 12AX7			

TYPE 265-A Q COMPARATOR ELECTRICAL COMPONENTS PARTS LIST (Continued)

OSCILLATOR-DETECTOR UNIT

Circuit Symbol	Value	Description	BRC Part No.	Mfg.	Mfg's. Type No.
V301		Tube, Electron: CRT 5ABP1			
V302-304		Tube, Voltage Regulator: OA2			
V305		Tube, Voltage Regulator: OD3 (Used on Q Comparators beginning with Serial Number 35.)			

APPENDIX

CAPACITANCE (OR INDUCTANCE) AND FREQUENCY RELATIONSHIP

The relationship between capacitance (or inductance) and frequency is shown by

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Since capacitance is the actual reactance varied, this may be written:

$$f = \frac{1}{2\pi\sqrt{L}\sqrt{C}} = \frac{K}{\sqrt{C}} = KC^{-\frac{1}{2}}$$

$$\text{where } K = \frac{1}{2\pi\sqrt{L}}.$$

Now at +20% limit of reactance,

$$f_2 = \frac{K}{\sqrt{C_2}} = \frac{K}{\sqrt{1.2C}} = \frac{K}{1.093}C^{-\frac{1}{2}} = 0.914KC^{-\frac{1}{2}}$$

$$\text{In percent, } \triangle f = \frac{f_2 - f}{f} \times 100$$

$$\triangle f = \frac{(0.914-1)\ KC^{-\frac{1}{2}}}{KC^{-\frac{1}{2}}} \times 100 = -0.086 \times 100$$

$$\triangle f = -8.6\%.$$

$$\text{Similarly: } f_1 = \frac{K}{\sqrt{0.8C}} = 1.12KC^{-\frac{1}{2}} \text{ and}$$

$$\triangle f = \frac{f_1 - f}{f} \times 100 = 0.12 \times 100 = +12\%.$$

A similar process using

$$f = \frac{1}{2\pi\sqrt{C}\sqrt{L}} = KL^{-\frac{1}{2}} \text{ where } K = \frac{1}{2\pi\sqrt{C}} \text{ yields}$$

identical results.

CALCULATION OF PERCENTAGE DEVIATION OF Q AGAINST FREQUENCY

Assuming a test frequency of 2 mc, the variation of Q with frequency of the test standard is determined as follows:

(1) Measure the Q of the test standard (on a 260-A Q Meter) at zero reactance or 2 mc. Assume the Q is 100.

(2) Measure the Q of the test standard at a frequency 8.6% lower than 2 mc or 1.828 mc. Assume the Q is 110. This means that the Q is 10 percent higher at a frequency 8.6% lower than the test frequency (corresponding to +20% reactance on the L-C scale of the Q Comparator).

(3) Measure the Q of the test standard at a frequency +12% higher than 2 mc or 2.24 mc. Assume the Q is 90. This means that the Q of the standard is 10% lower at a frequency +12% higher than the test frequency (corresponding to —20% reactance on the L-C scale of the Q Comparator).

(4) The marking on the Q Comparator reticule representing the expected Q variation of the test standard would then be drawn to reflect a 10% high Q reading at the —20% end of the reactance scale and a 10% low reading at the +20% end of the reactance scale. Tolerance lines would then be drawn parallel to the standard line (above and below) to indicate the desired tolerance as shown in Figure 12.

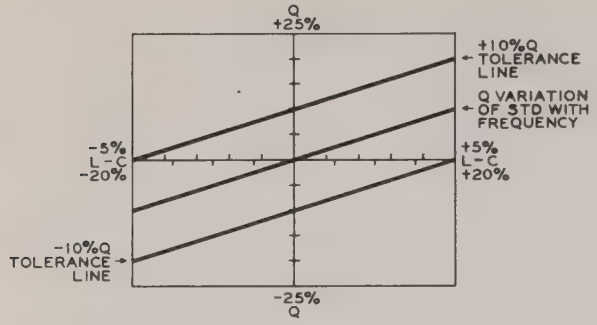


Figure 13. Marking Of Q Tolerances

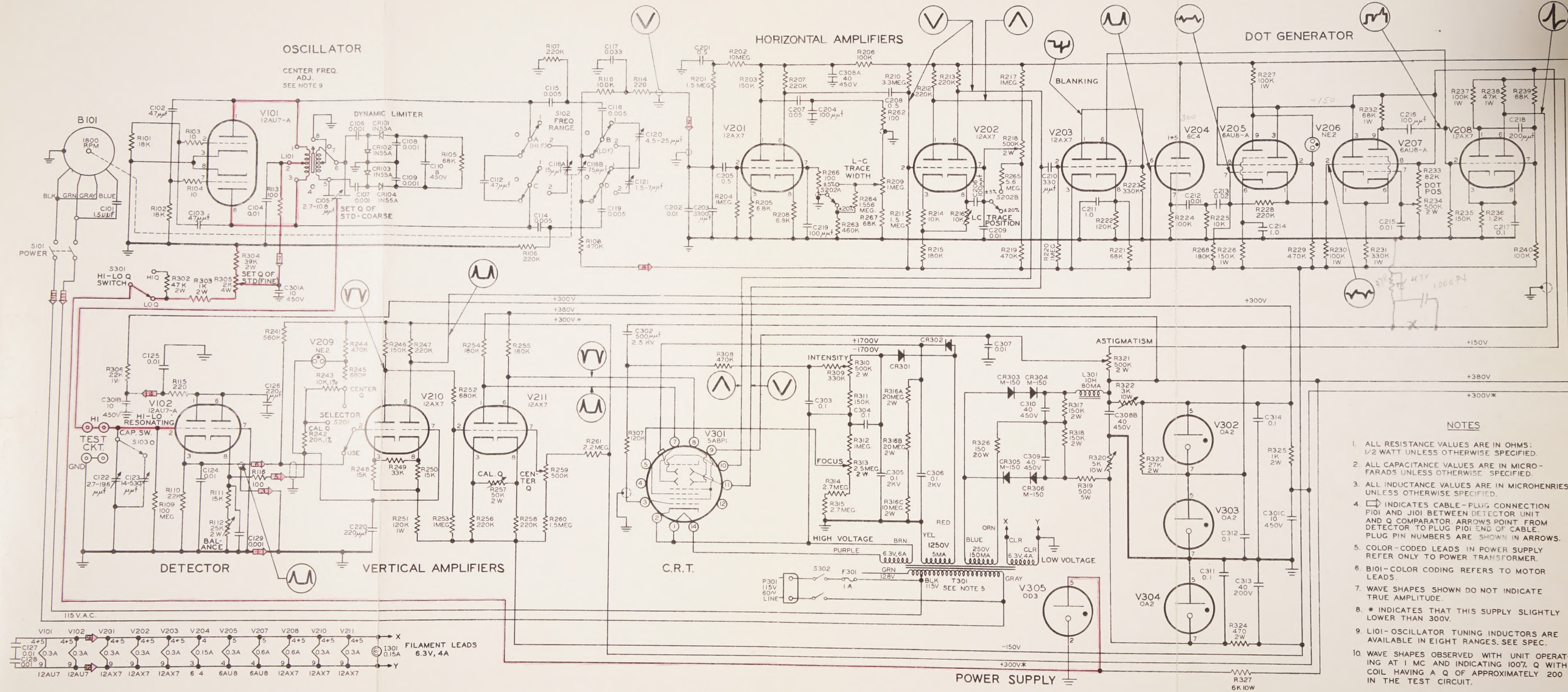
PRECISE SETTING OF TEST CIRCUIT CENTER FREQUENCY

1. Secure an oscillator or signal source of the desired accuracy and covering the desired frequency range. It should be capable of supplying 1 volt or more to a 50-ohm load.

2. Loosely couple the output of this source to a test coil which is resonated approximately at the desired frequency and centered on the CRT as in step 11 under "Setting Q of Standard", Section II.

3. As the external oscillator is tuned through the test circuit resonance, the dot will appear to oscillate up and down due to the beat frequency generated. The point of maximum excursion indicates near equality between the 265-A oscillator frequency and the external oscillator frequency at the peak of the test circuit resonance.

4. The 520-A Oscillator Inductor tuning control may now be adjusted to position the dot so that it indicates the test circuit resonant frequency on the CRT to within $\pm 0.5\%$ of the external oscillator.



NOTES

1. ALL RESISTANCE VALUES ARE IN OHMS; 1/2 WATT UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITANCE VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
3. ALL INDUCTANCE VALUES ARE IN MICROHENRIES UNLESS OTHERWISE SPECIFIED.
4. ⇨ INDICATES CABLE-PLUG CONNECTION P101 AND J101 BETWEEN DETECTOR UNIT AND Q COMPARATOR. ARROWS POINT FROM DETECTOR TO PLUG P101 END OF CABLE. PLUG PIN NUMBERS ARE SHOWN IN ARROWS.
5. COLOR-CODED LEADS IN POWER SUPPLY REFER ONLY TO POWER TRANSFORMER.
6. B101-COLOR CODING REFERS TO MOTOR LEADS.
7. WAVE SHAPES SHOWN DO NOT INDICATE TRUE AMPLITUDE.
8. * INDICATES THAT THIS SUPPLY SLIGHTLY LOWER THAN 300V.
9. L101-OSCILLATOR TUNING INDUCTORS ARE AVAILABLE IN EIGHT RANGES. SEE SPEC.
10. WAVE SHAPES OBSERVED WITH UNIT OPERATING AT 1 MC AND INDICATING 100% Q WITH COIL HAVING A Q OF APPROXIMATELY 200 IN THE TEST CIRCUIT.

Figure 14. Schematic Diagram

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